Reduced Blood Osmalality in Freshwater-adapted European O-group Flounder, Platichthys flesus (L.), Exposed to Environmental Levels of Sediment-associated Tributyl- and Triphenyltin

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Following the partial bans on the use of organotin-based anti-fouling paints on boats and maritime equipment in most industrialized countries, water concentrations of tributyltin (TBT) have dropped dramatically, albeit with hotspots remaining in areas of intense concentrations of tributyltin (TBT) have dropped dramatically, yet widely distributed in marine and freshwater sediments, that act as both reservoirs of the element and sources for the secondary introduction of organotins to the environment (Valkirs and Seligman, 1996). Preliminary experiments showed that there was an inhibitory effect of TBT in vitro on the osmoregulatory enzyme Na⁺/K⁺-dependent ATPase. Subsequent in vivo experiments conducted to evaluate their potential effect on osmoregulation have focused on organotins in aqueous suspension, rather than sedimentary sources. In the latter studies, no changes in blood osmolalities were found in freshwater adapted rainbow trout (Oncorhynchus mykiss) exposed to acutely toxic concentrations of tributyltin oxide (Chlamavitch and Kuhn, 1977). A similar observation was made by Pinkney et al. (1989) for juvenile striped bass (Morone saxatilis) adapted to 50% seawater and exposed to sublethal concentrations of tributyltin oxide; these authors also found a significantly enhanced Na⁺/K⁺-ATPase activity.

The aim of the present study was to evaluate the effects of organotin-contaminated sediments on aspects of the osmoregulation of a benthic euryhaline fish, the European flounder Platichthys flesus. O-group flounders (0.02–1.3 g wet weight) were collected in the Itchen River estuary just below Woodmill, Southampton, UK. Stock populations of flounders were kept in an outdoor 3500 l glass fibre fish farming tank, shielded from direct sunlight and rain by a roof, but subject to natural temperature fluctuations and light/dark cycles. Prior to experimentation, the fish were selected from the stock populations and acclimated to tapwater at a temperature of 15°C and a light/dark regime of 12/12 h for at least 1 week. Fish were fed ad libitum on live brine shrimp (Artemia salina) during both acclimation and the 5-week experimental period, but starved for 24 h prior to sampling for analytical tests.

The exposure experiments were performed in 25 l polyethylene buckets (Carter et al., 1989) containing organotin-contaminated fine-grained silica sand (horticultural ‘Silver Sand’, grain size <1 mm). The water was continuously aerated and was changed once a week. To produce the required sediment concentrations of organotins, tributyltin chloride (TBTCl) or triphenyltin chloride (TPhTCI) in glacial acetic acid were first adsorbed to approximately 20 g of fine deep-sea mud, obtained from Porcupine abyssal plain (north-east Atlantic; organotin concentrations <1 ng g⁻¹) to reduce leaching. This mud was then mixed into the sand in separate buckets to produce final sediment concentrations of 150 ng g⁻¹ dry weight. This concentration was chosen as representative of local concentrations of organotins in sediment, as measured for TBT by Langston et al. (1994). Preliminary experiments showed that the calculated half-life for sediment-associated TBT was significantly higher than that for TPhT (p < 0.05). TBT and TPhT concentrations declined from 150 to
121 ng g$^{-1}$ and 151–107 ng g$^{-1}$, respectively, during a 42-day incubation. Extrapolation of these values indicated a half-life of 95 days for TBT and 85 days for TPhT. The organic degradation products of TBT, dibutyltin (DBT) and monobutyltin (MBT), peaked at concentrations of 8.9 and 8.3 ng g$^{-1}$, respectively. The diphenyltin (DPhT) concentration peaked at 48 ng g$^{-1}$, while phenyltin (MPhT) was not detected. Sediment samples for organotin analysis were taken immediately after dosing and again at the end of the 5-week experiment, and were stored at $-20^\circ$C. Organotin analysis was performed by gas chromatography with flame photometric detection (GC-FPD) after hydride generation, according to the method of Waldock et al. (1989). The osmotic concentrations of blood samples and the surrounding medium were measured by the cryoscopic method of Ramsay and Brown (1955). Statistical analysis of the data was carried out using a one-way ANOVA, and linear regressions were used to examine the dependency of osmolalities of the fish in the two organotin groups ($p < 0.05$) when compared to a control group. There was no significant difference between the blood osmolalities of the fish in the two organotin groups ($p > 0.05$). The values for blood osmolalities in all three groups were independent of fish size ($r = 0.17$, 0.22 and 0.21, respectively). Throughout the experimental period, the fish were in constant contact with the contaminated sediment, being either on top of the substrate or partially buried. This experiment is believed to represent a realistic pattern of how a benthic species interacts with sediment-associated organotins and of some of the consequent effects on osmoregulation.

It is considered that benthic fish which are in contact with contaminated sediments are more likely to suffer adverse effects to their osmoregulatory system than pelagic species. This source of exposure may be more important than organotins in the water column, especially as far higher concentrations in water seemed to have little effect on blood osmolality in previous studies (Chlamiovitch and Kuhn, 1977; Pinkney et al., 1989). The results presented here show that tributyltin- and triphenyltin chlorides in sediments are capable of significantly disrupting the osmoregulatory functions of an estuarine fish, at concentrations currently found in local sediments.

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Polychlorinated Biphenyls in Surface Sediments from the Pearl River Delta and Macau

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Polychlorinated biphenyls (PCBs) are ubiquitous contaminants, being found in all parts of the global ecosystem. Their extreme persistence and adverse impacts in aquatic systems in particular have been widely documented in the last three decades, and have given rise to controls or bans on their manufacture and use in many countries. However, approximately one million tonnes of PCBs were manufactured in total during the 1900s, and these compounds continue to be released to the open environment (Tanabe, 1988).

In China, about 10000 t of PCBs were produced in the decade from 1965 to 1975, and these were known as PCB3 and PCB8. About 10% of this cumulative tonnage was employed as additives to paint, with the remainder being utilized in the electrical industry (Jing et al., 1992; Yang et al., 1997).

Due to their hydrophobic nature, PCBs have a strong affinity for particulate materials in aquatic ecosystems. The bottom sediments of estuarine and coastal areas therefore constitute one of the primary sinks for PCBs (Chou and Griffin, 1986). Studies of PCBs in sediments have been widespread, as a result (e.g. see Mangani et al., 1991; Onsuka and Davies, 1991; Chu et al., 1995; Hess et al., 1995; Muir et al., 1996; Pierard et al., 1996; Gevao et al., 1997).

The Pearl River in southern China runs through Guangzhou city, and the Delta extends to include both Hong Kong and Macau. This is one of the most developed regions of China in economic terms. However, the high population densities and heavy industrial development in this area as a whole have created significant pollution, affecting the regional air and water quality. Although major efforts were made during the 1980s to

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